

# PATENT ABSTRACTS OF JAPAN

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## (54) ELASTIC SURFACE WAVE GYROSCOPE

(57)Abstract:

**PROBLEM TO BE SOLVED:** To reduce position accuracy of an IDT(interdigital transducer) or the like without lowering the detection accuracy.

**SOLUTION:** An IDT 101 for detecting a Coriolis force is arranged at the center of the surface of a piezo-electric substrate. IDTs 102 and 103 for generating elastic surface waves on both sides thereof and moreover reflector pairs 104 and 105 on both sides thereof... all in one row. A detection signal of the IDT 101 is inputted into a positive terminal of a differential amplifier 34 of a detection circuit 31. A high frequency oscillator 32 using an elastic surface wave resonator is built on the piezo-electric substrate and an output thereof is inputted into the IDTs 102 and 103 and a phase shifter 33 of the detection circuit 31. The phase shifter 33 corrects a phase based on distances between the IDT 101 and the IDTs 102 and 103 to generate a signal corresponding to a detection signal component attributed to the elastic surface wave as vibration source. A signal component attributed to the elastic surface wave is removed by the differential amplifier 34 from the detection signal of the IDT 101 and the detection signal component alone attributed to the Coriolis force is detected.

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## CLAIMS

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[Claim(s)]

[Claim 1] A surface acoustic wave gyroscope comprising:

A piezoelectric board.

An electrode for detection which detects Coriolis force which was formed in the surface of the above-mentioned piezoelectric board and in which voltage conversion was carried out by the piezo-electric effect.

An electrode for a drive of a couple which is formed in both outsides of the above-mentioned electrode for detection and generates a surface acoustic wave.

An electrode for antenna reflectors of a couple which is formed in both outsides of an electrode for a drive of the above-mentioned couple and reflects the above-mentioned surface acoustic wave in the above-mentioned electrode side for detection. A high frequency creating means which generates high frequency impressed to the above-mentioned electrode for a drive. A signal generating means which generates a signal equivalent to vibration based on the above-mentioned surface acoustic wave in which voltage conversion was carried out by the piezo-electric effect and a signal output means which outputs a difference signal of a detecting signal from the above-mentioned electrode for detection and an output signal from the above-mentioned signal generating means.

[Claim 2] A surface acoustic wave gyroscope comprising:

A piezoelectric board.

The 1st electrode for a drive to which the 1st high frequency is impressed in order to be formed in the above-mentioned piezoelectric board surface and to generate the 1st surface acoustic wave.

The 2nd electrode for a drive to which the 2nd high frequency is impressed in order to generate the 2nd surface acoustic wave that has frequency which is formed in the above-mentioned piezoelectric board surface and is different from the 1st surface acoustic wave of the above.

The 1st high frequency creating means that generates the 1st high frequency of the above and the 2nd high frequency creating means that generates the 2nd high frequency of the above. The 1st electrode for antenna reflectors of a couple that is formed in both outsides of the above 1st and the 2nd electrode for a drive in order to generate a standing wave of the 1st surface acoustic wave of the above and reflects the 1st surface acoustic wave of the above in the 1st electrode side for a drive. The 2nd electrode for antenna reflectors of a couple that is formed in both outsides of the above 1st and the 2nd electrode for a drive in order to generate a standing wave of the 2nd surface acoustic wave of the above and reflects the 2nd surface acoustic wave of the above in the 2nd electrode side for a drive. It is formed in both outsides of the above 1st and the 2nd electrode for a drive in order to make into a standing wave the 3rd surface acoustic wave based on Coriolis force generated by an interaction of an interference wave of the 1st surface acoustic wave and the 2nd surface acoustic wave and rotational movement of a piezoelectric board. The 3rd electrode for antenna reflectors of a couple that reflects the 3rd surface acoustic wave of the above in the 1st and 2nd electrode side for a drive. An electrode for detection which responds distorted and detects an electrical signal which is formed in the above 1st and the 2nd inter-electrode one for a drive and originates in the above-mentioned Coriolis force according to the piezo-electric effect and to generate and a signal generating means which generates a signal equivalent to vibration based on the 3rd elastic surfaces of the above in which voltage conversion was carried out by the piezo-electric effect. A signal output means which outputs a difference signal of a detecting signal from the above-mentioned electrode for detection and an output signal from the above-mentioned signal generating means.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the surface acoustic wave gyroscope which changes into voltage the Coriolis force generated in a substrate face by the interaction of the surface vibration by the surface acoustic wave of a piezoelectric board and rotational movement of a piezoelectric board according to the piezo-electric effect and detects it.

[0002]

[Description of the Prior Art] The gyroscope using a surface acoustic wave is proposed so that it may be shown in the former for example JP6-281465A.

[0003] In the above-mentioned gazette one interdigital type transducer of a piezoelectric board which detects Coriolis force on the surface on the other hand. (it is hereafter called IDT for detection (Inter-Digital Transducer).) -- IDT of the couple which inserts and generates the surface acoustic wave of the same frequency. (it is hereafter called IDT for a drive.) -- the surface acoustic wave gyroscope which has the composition which forms mutually the antenna reflector of a couple which reflects a surface acoustic wave in the outside of this IDT for a drive at the IDT side for detection by position relations is shown.

[0004] Drawing 21 is a figure showing the antenna reflector of IDT for detection formed in the piezoelectric board surface of the above-mentioned surface acoustic wave gyroscope IDT for a drive of a couple and a couple.

[0005] The Kushigata electrode D1 of IDT101 for detection formed in the surface of the piezoelectric board 100 and IDT102103 for a drive the distance d1 between D2 and d2 have an identical pitch (1/2 of the wavelength  $\lambda$  of a surface acoustic wave). The antenna reflector 104105 consists of a grating radiator which arranges the 100 line electrodes D3 with a predetermined pitch (pitch of abbreviated  $\lambda/2$ ).

[0006] The piezoelectric board 100 is generating the surface acoustic wave which advances from both sides to an outside direction by each IDT102103 for a drive respectively and reflecting this surface acoustic wave in the IDT101 side for detection with the antenna reflector 104105. The standing wave of a surface acoustic wave arises between the antenna reflectors 104105. IDT101 for detection is formed in each Kushigata electrode D1 and the prescribed position where D2 becomes a position of the paragraph of this surface acoustic wave (standing wave).

[0007] The above-mentioned surface acoustic wave gyroscope in the state where the surface of the piezoelectric board 100 was made to generate the standing wave of a surface acoustic wave. Since the surface acoustic wave (standing wave) by the Coriolis force about 90 degrees of phases shifted [ Coriolis force ] from this surface acoustic wave perpendicularly to the vibrating direction by a surface acoustic wave will occur if this piezoelectric board 100 rotates. The voltage corresponding to vibration of this surface acoustic wave changed from IDT101 for detection by the piezo-electric effect is detected.

[0008]

[Problem(s) to be Solved by the Invention] By the way since it separates from a surface

acoustic wave and he is trying for a surface acoustic wave gyroscope to detect only Coriolis force when the Kushigata electrode D1 and D2 arrange IDT101 for detection to the prescribed position used as the position of the paragraph of the standing wave of a surface acoustic wave. Detecting accuracy is difficult for manufacture of a highly precise surface acoustic wave gyroscope depending on the accuracy of the mutual physical relationship of IDT101 for detection IDT102103 for a drive and the antenna reflector 104105.

[0009] That is if the spatial phase contrast of IDT102103 for a drive and IDT101 for detection is not 90 degrees correctly the signal component resulting from the surface acoustic wave generated by 102103 for a drive to the signal detected by IDT101 for detection is contained and it becomes a factor of a detection error.

[0010] As for the accuracy of the formation position of one of these IDT101 for detection IDT102103 for a drive and the antenna reflector 104105 there is a fixed limit in precision improvement depending on the electrode formation art on the surface of a piezoelectric board.

[0011] In light of the above-mentioned problems this invention is a thing. The purpose is to provide the surface acoustic wave gyroscope which can reduce accuracy of positions such as IDT for detection without making it fall.

[0012]

[Means for Solving the Problem] An electrode for detection which detects Coriolis force in which this invention was formed in the surface of a piezoelectric board and the above-mentioned piezoelectric board and voltage conversion was carried out by the piezoelectric effect. An electrode for a drive of a couple which is formed in both outsides of the above-mentioned electrode for detection and generates a surface acoustic wave. An electrode for antenna reflectors of a couple which is formed in both outsides of an electrode for a drive of the above-mentioned couple and reflects the above-mentioned surface acoustic wave in the above-mentioned electrode side for detection. A high frequency creating means which generates high frequency impressed to the above-mentioned electrode for a drive and a signal generating means which generates a signal equivalent to vibration based on the above-mentioned surface acoustic wave in which voltage conversion was carried out by the piezo-electric effect. It has a signal output means which outputs a difference signal of a detecting signal from the above-mentioned electrode for detection and an output signal from the above-mentioned signal generating means (claim 1).

[0013] According to the above-mentioned composition if high frequency of frequency  $f_0$  is impressed to an electrode for a drive of a couple respectively a surface acoustic wave which vibrates by frequency  $f_0$  to a substrate face according to an inverse piezoelectric effect will occur and this surface acoustic wave will be spread to both outsides of each electrode for a drive.

[0014] It is spread to an electrode for antenna reflectors respectively it is reflected in the electrode side for detection by this electrode pair for antenna reflectors and a standing wave of a surface acoustic wave generates a surface acoustic wave in the inter-electrode one of a couple for antenna reflectors.

[0015] And rotational movement of a piezoelectric board will generate a surface acoustic wave of frequency  $f_0$  based on Coriolis force about 90 degrees of phases shifted [ Coriolis

force ] from this surface acoustic wave in a field which intersects perpendicularly with a wave front of a surface acoustic wave in the state where a substrate face is vibrating by a standing wave of the above-mentioned surface acoustic wave. It is provided in a predetermined relation position to a standing wave of a surface acoustic wave based on Coriolis force and as for an electrode for detection an electrical signal which originates in Coriolis force according to the piezo-electric effect and which responds distorted and is generated is detected from an electrode for detection.

[0016] A signal equivalent to a signal which changes distortion which originates in a surface acoustic wave generated by an electrode for a drive on the other hand according to the piezo-electric effect is generated and a difference signal of this signal and detecting signal is outputted as a detecting signal of Coriolis force. That is a signal component corresponding to a surface acoustic wave of a vibration source included in a detecting signal in an electrode for detection is removed and only a signal component corresponding to Coriolis force is outputted.

[0017] A piezoelectric board and the 1st electrode for a drive to which the 1st high frequency is impressed so that this invention may be formed in the above-mentioned piezoelectric board surface and it may generate the 1st surface acoustic wave. The 2nd electrode for a drive to which the 2nd high frequency is impressed in order to generate the 2nd surface acoustic wave that has frequency which is formed in the above-mentioned piezoelectric board surface and is different from the 1st surface acoustic wave of the above. The 1st high frequency creating means that generates the 1st high frequency of the above and the 2nd high frequency creating means that generates the 2nd high frequency of the above. The 1st electrode for antenna reflectors of a couple that is formed in both outsides of the above 1st and the 2nd electrode for a drive in order to generate a standing wave of the 1st surface acoustic wave of the above and reflects the 1st surface acoustic wave of the above in the 1st electrode side for a drive. The 2nd electrode for antenna reflectors of a couple that is formed in both outsides of the above 1st and the 2nd electrode for a drive in order to generate a standing wave of the 2nd surface acoustic wave of the above and reflects the 2nd surface acoustic wave of the above in the 2nd electrode side for a drive. It is formed in both outsides of the above 1st and the 2nd electrode for a drive in order to make into a standing wave the 3rd surface acoustic wave based on Coriolis force generated by an interaction of an interference wave of the 1st surface acoustic wave and the 2nd surface acoustic wave and rotational movement of a piezoelectric board. The 3rd electrode for antenna reflectors of a couple that reflects the 3rd surface acoustic wave of the above in the 1st and 2nd electrode side for a drive. An electrode for detection which responds distorted and detects an electrical signal which is formed in the above 1st and the 2nd inter-electrode one for a drive and originates in the above-mentioned Coriolis force according to the piezo-electric effect and to generate. It has a signal generating means which generates a signal equivalent to vibration based on the 3rd elastic surfaces of the above in which voltage conversion was carried out by the piezo-electric effect and a signal output means which outputs a difference signal of a detecting signal from the above-mentioned electrode for detection and an output signal from the above-mentioned signal generating means (claim 2).

[0018] According to the above-mentioned composition if the 1st high frequency of frequency  $f_H (=f_0 + \Delta f)$  is impressed to the 1st electrode for a drive for example the 1st surface acoustic wave that vibrates by frequency  $f_H$  to a substrate face according to an

inverse piezoelectric effect will occur and this 1st surface acoustic wave will be spread to both outsides of the 1st electrode for a drive.

[0019] If the 2nd high frequency of frequency  $f_L (=f_0 - \Delta f)$  is impressed to the 2nd electrode for a drive, for example, the 2nd surface acoustic wave that vibrates by frequency  $f_L$  to a substrate face according to an inverse piezoelectric effect will occur and this 2nd surface acoustic wave will be spread to both outsides of the 2nd electrode for a drive.

[0020] The 1st surface acoustic wave is spread to the 1st electrode for antenna reflectors of a couple without being reflected by the electrode for detection, 2nd electrode for drive, 2nd and 3rd electrode for antenna reflectors. It is reflected in the 1st electrode side for a drive by this 1st electrode pair for antenna reflectors and a standing wave of the 1st surface acoustic wave occurs in the 1st inter-electrode one of a couple for antenna reflectors.

[0021] Similarly, the 2nd surface acoustic wave is spread to the 2nd electrode for antenna reflectors of a couple without being reflected by the electrode for detection, 1st electrode for drive, 1st and 3rd electrode for antenna reflectors. It is reflected in the 2nd electrode side for a drive by this 2nd electrode pair for antenna reflectors and a standing wave of the 2nd surface acoustic wave occurs in the 2nd inter-electrode one of a couple for antenna reflectors.

[0022] In and the state where an interference wave (surface acoustic wave) of frequency  $f_0$  occurs by the 1st and 2nd elastic-surfaces wave interference in the 1st electrode for a drive and the 2nd inter-electrode one for a drive and a substrate face is vibrating by this interference wave. Rotational movement of a piezoelectric board will generate the 3rd surface acoustic wave of frequency  $f_0$  based on Coriolis force about 90 degrees of phases shifted [ Coriolis force ] from this interference wave in a field which intersects perpendicularly with a wave front of an interference wave.

[0023] It is spread to the 3rd electrode for antenna reflectors of a couple without being reflected by the 1st and 2nd electrode for a drive, it is reflected in the electrode side for detection by this 3rd electrode pair for antenna reflectors and a standing wave of the 3rd surface acoustic wave generates the 3rd surface acoustic wave in the 3rd inter-electrode one of a couple for antenna reflectors.

[0024] It is provided in a predetermined relation position to a standing wave of the 3rd surface acoustic wave of the above and as for an electrode for detection, an electrical signal which originates in the 3rd surface acoustic wave of the above according to the piezo-electric effect and which responds distorted and is generated is detected from an electrode for detection.

[0025] A signal equivalent to a signal which on the other hand changes distortion resulting from the 3rd surface acoustic wave of the above according to the piezo-electric effect is generated and a difference signal of this signal and detecting signal is outputted as a detecting signal of Coriolis force. That is a signal component corresponding to the 3rd surface acoustic wave of a vibration source included in a detecting signal in an electrode for detection is removed and only a signal component corresponding to Coriolis force is outputted.

[0026]

[Embodiment of the Invention] Drawing 1 is a lineblock diagram of the surface acoustic wave gyroscope concerning this invention. Drawing 2 is a figure showing the electrode structure formed in the piezoelectric board.

[0027]The gyroscope 1 is provided with the sensing element 2 which detects Coriolis force and the high-frequency oscillators 3 and 4 which are the driving sources of a surface acoustic wave.

[0028]The transducer 22 frequency  $f_H (=f_0+\Delta f)$  which detect Coriolis force on this 1 surface while the sensing element 2 has the rectangular piezoelectric board 21 [Hz] The transducer 23 frequency  $f_L (=f_0-\Delta f)$  which generate a surface acoustic wave [Hz] The primary detecting element of the transducer 24 which generates a surface acoustic wave and a pair each of antenna reflectors 25 25' (drawing 1 and "A" show.) the antenna reflector 26 26' (drawing 1 and "B" show.) the antenna reflector 27 and the Coriolis force that consists of 27' (drawing 1 and "C" show.) is formed.

[0029]Transducers 22-24 and antenna reflector 25 25'-27 and 27' is arranged by the longitudinal direction of the piezoelectric board 21 at the single tier. The transducer 22 for Coriolis force detection is arranged in the approximately center of the piezoelectric board 21 As this transducer 22 is inserted on that left-hand side The surface acoustic wave of frequency  $f_H$ . (It is hereafter called the 1st surface acoustic wave.) The transducer 23 for generating is arranged and the transducer 24 for surface acoustic wave (henceforth 2nd surface acoustic wave) generating of frequency  $f_L$  is arranged on the right-hand side of the transducer 22. Antenna reflector 27' 26' and 25' are arranged sequentially from [ this ] a central site at the outside of the transducer 24 and similarly the antenna reflectors 27 25 and 26 are arranged sequentially from [ this ] the central site at the outside of the transducer 23.

[0030]The high-frequency oscillator 3 is an oscillator which generates the high frequency of frequency  $f_H$  and the high-frequency oscillator 4 is an oscillator which generates the high frequency of frequency  $f_L$ . The high-frequency oscillators 3 and 4 consist of a surface acoustic wave oscillator using the surface acoustic wave resonator constituted on the piezoelectric board which consists of the same raw material as the piezoelectric board 21 Output terminal b-b' of the high-frequency oscillator 3 is connected to the transducer 23 and output terminal c-c' of the high-frequency oscillator 4 is connected to the transducer 24.

[0031]In the C-B Pierce oscillating circuit shown in the B-E Pierce oscillating circuit or drawing 4 shown for example in drawing 3 the high-frequency oscillators 3 and 4 are realizable by constituting the resonant element  $\theta$  from a surface acoustic wave resonator shown in drawing 5. The surface acoustic wave resonator shown in drawing 5 arranges the grating antenna reflectors (open sand mold grating antenna reflector) 29 and 30 which arrange many line electrodes D on piezoelectric board 21' at the both sides of the Inta digital type transducer (henceforth IDT) 28. The resonance frequency of the surface acoustic wave resonator of the high-frequency oscillator 3 is set as  $(f_0+\Delta f)$  and the resonance frequency of the surface acoustic wave resonator of the high-frequency oscillator 4 is set as  $(f_0-\Delta f)$ .

[0032]As for the high frequency oscillation ways 3 and 4 although the thing using the high oscillator of a crystal oscillator and other Q may be sufficient as them when taking into consideration stabilization of the temperature characteristics of the gyroscope 1 it is preferred to constitute from an oscillator using the surface acoustic wave resonator which comprises same piezoelectric member as the piezoelectric board 21.

[0033]For example when  $\text{LiNbO}_3$  is used as a raw material of the large piezoelectric board 21 of electromechanical coupling coefficient  $k^2$  When the temperature

characteristics set about 70 ppm of resonance bands of \*\*\*\*antenna reflector 2525'-27and 27' to 5 MHzfor examplein the temperature requirement (-20 \*\* - 50 \*\*) which are anticipated-use conditionsthe resonance characteristic of antenna reflector 2525'-27and 27' may shift from a predetermined resonance band. Although the antenna reflector 25 and 25' reflect the 1st surface acoustic wave and generate a standing waveit becomes impossible for exampleto obtain the standing wave of the 1st surface acoustic wave of the stable levelif the resonance characteristic of the antenna reflector 25 and 25' carries out a drift by a temperature change and sufficient reflection property is no longer obtained. This is the same also about the antenna reflector 2626' and the antenna reflector 27and 27'.

[0034]A surface acoustic wave gyroscope is what detects the Coriolis force generated by the interaction of this surface vibration and rotational movement when a piezoelectric board rotateswhere surface vibration is carried out a piezoelectric boardAlthough the stability of the frequency (namelyfrequency of a surface acoustic wave) of surface vibration of a piezoelectric board is also importantthe amplitude of surface vibration of a piezoelectric board at the point of the detection sensitivity of Coriolis force is more important.

[0035]For this reasonthe surface acoustic wave resonator which consists of the same piezoelectric member as the gyroscope 1 constitutes the oscillation element of the high frequency oscillation ways 3 and 4 from this embodimentHe is trying to attain stabilization of the standing wave of the 1st and 2nd surface acoustic wave by carrying out the drift of the oscillation characteristic of the high frequency oscillation ways 3 and 4 according to the drift of the resonance characteristic of antenna reflector 2525'26and 26'.

[0036]In this embodimentthe resonance frequency of the surface acoustic wave resonator theta of the high-frequency oscillator 3 carries out a drift to  $(f_0 + \Delta f + \Delta f_i)$  from  $(f_0 + \Delta f)$  by a temperature changeWhen oscillating frequency is changedit is the resonance frequency (.) of the antenna reflector 25 and 25'. Namelysince the drift also of the reflection frequency is carried out to  $(f_0 + \Delta f + \Delta f_i)$  from  $(f_0 + \Delta f)$ Also when the frequency of the 1st surface acoustic wave that the substrate face of the piezoelectric board 21 was made to generate is changedthe 1st surface acoustic wave is suitably reflected by the antenna reflector 25 and 25'and stabilization to the temperature change of the amplitude of the 1st surface acoustic wave (standing wave) is attained. Similarly the resonance frequency of the surface acoustic wave resonator theta of the high frequency oscillation way 4 carries out a drift to  $(f_0 - \Delta f + \Delta f_i)$  from  $(f_0 - \Delta f)$  by a temperature changeSince the drift also of the resonance frequency of the antenna reflector 26 and 26' is carried out to  $(f_0 - \Delta f + \Delta f_i)$  from  $(f_0 - \Delta f)$  when oscillation cycle change is carried outAlso when the frequency of the 2nd surface acoustic wave that the substrate face of the piezoelectric board 21 was made to generate is changedthe 2nd surface acoustic wave is suitably reflected by the antenna reflector 26 and 26'and stabilization to the temperature change of the amplitude of the 2nd surface acoustic wave (standing wave) is attained.

[0037]Thereforealthough the 1st and 2nd elastic-surfaces wave interference wave changes the frequency to  $(f_0 + \Delta f_i)$  to a temperature changethe amplitude fluctuation is reduced and can raise the temperature characteristics of the disregard level of the Coriolis force generated by the interaction of an interference wave and rotational movement of the piezoelectric board 21.

[0038]Although the high-frequency oscillators 3 and 4 may be constituted separately



from the sensing element 2 they are good to form the surface acoustic wave resonator theta on the substrate of the piezoelectric board 21 preferably and to constitute on this substrate. If it does in this way the gyroscope 1 can be constituted compactly.

[0039] The piezoelectric board 21 consists of a member which has the piezo-electric effects such as lead zirconate titanate ( $\text{PbTiO}_3\text{PbZrO}_3$ ),  $\text{LiNbO}_3$  and  $\text{LiTaO}_3$  for example. The transducers 22-24 comprise an interdigital form transducer (IDT) which forms the electrode D1 of mutually crossing Kushigata and the thin film of D2 in the surface of the piezoelectric board 21.

[0040] The frequency of a surface acoustic wave is determined in the Kushigata electrode D1 of the transducers 23 and 24 and the pitch d of D2. Its high frequency is preferred when the frequency of the surface acoustic wave as a vibration source of the piezoelectric board 21 can select proper frequency and a miniaturization is taken into consideration. Although it is also possible to use the high frequency from the field of the Kushigata electrode D1 and the processing technology of D2 to several gigahertz, high frequency-ization has fixed restrictions from another factor such as a manufacturing cost and the frequency which is 10-100 MHz is usually used.

[0041] The transducer 23 (henceforth IDT23 for a drive) for the 1st surface acoustic wave generating The electrode D1 of Kushigata and the inter-electrode pitch d of D2 are set as wavelength  $\lambda_H (=v_0/f_H v_0$ ; propagation velocity in a free surface) of the 1st surface acoustic wave. As for the transducer 24 (henceforth IDT24 for a drive) for the 2nd surface acoustic wave generating the electrode D1 of Kushigata and the inter-electrode pitch d of D2 are set as wavelength  $\lambda_L (=v_0/f_L)$  of the 2nd surface acoustic wave. IDT23 for a drive and 24 are formed in the relation position which N wave numbers (N is a natural number) of frequency  $\Delta f$  may produce between IDT(s) 23 and 24 for a drive as shown in drawing 6.

[0042] The transducer 22 (henceforth IDT22 for detection) for Coriolis force detection The electrode D1 of Kushigata and the inter-electrode pitch d of D2 are set as wavelength  $\lambda_0 (=v_0/f_0)$  of the surface acoustic wave (henceforth an interference wave) of frequency  $f_0$  produced by interference with the 1st surface acoustic wave and the 2nd surface acoustic wave. IDT22 for detection is arranged so that each Kushigata electrode D1 of IDT22 for detection and D2 may be located in the position of the paragraph of the standing wave of the interference wave generated between IDT23 for a drive and IDT24 for a drive so that it may mention later.

[0043] Much the antenna reflector 25 25' the antenna reflector 26 26' and antenna reflectors 27 and 27' consist of an open sand mold grating antenna reflector which arranges the line electrode D3 of a book with a predetermined pitch.

[0044] The antenna reflector 25 and 25' reflect the 1st surface acoustic wave in the IDT23 side for a drive and generate the standing wave of the 1st surface acoustic wave between the antenna reflector 25 and 25'. The antenna reflector 25 and 25' so that center frequency may become frequency  $f_H (=f_0 + \Delta f)$  of the 1st surface acoustic wave. The inter-electrode pitch P1 is set as one half of wavelength  $\lambda_H$  of the 1st surface acoustic wave and the number (this embodiment 100) of the line electrode D3 is set up so that bandwidth may become in less than  $2\Delta f$ . Since the reflexogenic-zone region of the antenna reflector 25 is  $f_H \pm \Delta f$  ( $f_0 - f_0 + 2\Delta f$ ) the IDT24 for drive to 2nd surface acoustic wave (frequency  $f_L = f_0 - \Delta f$ ) is penetrated without being reflected with the antenna reflector 25 and is spread to the antenna reflector 26.

[0045]The antenna reflector 25 and 25' are formed in the predetermined relation position to IDT23 for a drive so that the 1st surface acoustic wave may be reflected efficiently.

[0046]If the interval of an antenna reflector and IDT for a drive is made into the distance L of the center of line electrode  $D_{ref}$  of an antenna reflector most located in the IDT side for a drive and the center to center of Kushigata electrode  $D_{drv}$  of IDT for a drive most located in the antenna reflector side as shown in drawing 7 Generally in the case of the antenna reflector of an open sand mold an antenna reflector is formed in the relation position with which this interval L is satisfied of  $L = (k+1/4) \lambda/2$  ( $k=12$  and  $3--$ ). Since the wavelength (or propagation velocity) in this portion changes when there is a portion of a propagation medium which is a thing when an elastic-surfaces wave propagation medium is uniform and is different on a propagation path the upper type needs to amend the distance of that portion.

[0047]In this embodiment since the antenna reflector 27 is formed between IDT23 for a drive and the antenna reflector 25 for example in the case of the position of the antenna reflector 25 to IDT23 for a drive It is necessary to amend the distance of the section of the antenna reflector 27 and the antenna reflector 25 is arranged at the position with which it is satisfied of the conditional expression of interval L' explained below to IDT23 for a drive.

[0048]The conditional expression of the above-mentioned interval L is determined as the standard in the wavelength  $\lambda$  of the surface acoustic wave in the free surface in which the metal tunic is not formed. As shown in drawing 8 in the portion in which the metal tunics D such as an antenna reflector are formed in the surface of the substrate 21 as compared with a free surface propagation velocity becomes slow and as for the surface acoustic wave W wavelength  $\lambda'$  in a metal film formation portion becomes shorter than the wavelength  $\lambda$  in a free surface seemingly.

[0049]Now if a shortening coefficient of wavelength is set to K distance  $q\lambda$  for q wavelength will be shortened by  $K-q\lambda$  on the metal film formation surface in a free surface. The conditional expression of the interval L1 at the time of assuming that the antenna reflector 27 is not formed between the antenna reflector 25 and IDT23 for a drive becomes  $L1 = (k+1/4) \lambda_H/2$  ( $k=12$  and  $3--$ )  $\lambda_H = v_0/f_H$  as mentioned above. Supposing the portion for r wavelength comprises the antenna reflector 27 among this interval L1 the distance L2 of the portion of the antenna reflector 27 will become  $K-r\lambda_0$  and only  $-(1-K)r\lambda_0$  will become short as compared with the case of a free surface.

[0050]Therefore the conditional expression of interval L' between IDT23 for a drive in case the antenna reflector 27 exists and the antenna reflector 25 which should be satisfied becomes  $L' = L1 - (1-K)r\lambda_0$ . Now if m and elastic-surfaces wave propagation speed in the portion of the antenna reflector 27 are made into  $v_m$  the number of the line electrode D3 of the antenna reflector 27 Since it is  $m=2r$  and  $K = \lambda_m/\lambda_0 = v_m/v_0$  it is  $-(1-K)r\lambda_0 = (1-v_m/v_0) \cdot (m/2) \cdot (v_0/f_0)$  Becoming  $= m \cdot (v_0 - v_m)/(2f_0)$  L' becomes like following \*\* type.

[0051]

[Equation 1]

[0052]For example when  $\text{LiNbO}_3$  128-degree X-Y is used as a piezoelectric material since

elastic-surfaces wave velocity  $v_m$  in 3960 m/s and a metal film formation portion are about 3920 m/s. elastic-surfaces wave velocity  $v_0$  in a free surface  $f_0=60\text{MHz}$   $\Delta f =$  if 5 MHz  $k=113$  and  $m=100$  interval  $L'$  of IDT23 for a drive and the antenna reflector 25 will be set to 3424.05 micrometer ( $=113.5 \times 3960 / 130 - 100 \times 40 / 120$ ).

[0053] in addition -- an antenna reflector -- 25 -- ' -- \*\*\*\*\* -- an antenna reflector -- 25 -- the same -- detection -- \*\* -- IDT -- 22 -- a drive -- \*\* -- IDT -- 24 -- and -- an antenna reflector -- 27 -- ' -- 26 -- ' -- it can set -- wavelength -- shortening -- having taken into consideration -- a drive -- \*\* -- IDT -- 23 -- an antenna reflector -- 25 -- ' -- between - - an interval --  $L$  -- " -- a conditional expression -- being satisfied -- as. It is formed in a prescribed position to IDT23 for a drive.

[0054] The antenna reflector 26 and 26' reflect the 2nd surface acoustic wave in IDT24 side for a drive and generate a standing wave of the 2nd surface acoustic wave between the antenna reflector 26 and 26'. The antenna reflector 26 and 26' so that center frequency may become frequency  $f_L (=f_0 - \Delta f)$  of the 2nd surface acoustic wave. The inter-electrode pitch  $P2$  is set as one half of wavelength  $\lambda_L$  of the 2nd surface acoustic wave and a number (this embodiment 100) of the line electrode D3 is set up so that bandwidth may become in less than  $2\Delta f$ . Since a reflexogenic-zone region of antenna reflector 26' is  $f_L \times \Delta f$  ( $f_0 - 2\Delta f - f_0$ ) the IDT24 for drive to 1st surface acoustic wave (frequency  $f_H = f_0 + \Delta f$ ) is penetrated without being reflected by antenna reflector 26' and is spread to antenna reflector 25'.

[0055] The antenna reflector 26 so that a predetermined conditional expression of an interval between IDT24 for a drive in consideration of wavelength shortening in IDT22 for detection IDT23 for a drive and the antenna reflectors 27 and 25 and the antenna reflector 26 may be satisfied. It is formed in a prescribed position to IDT24 for a drive and antenna reflector 26' is formed in a prescribed position to IDT24 for a drive so that a predetermined conditional expression of an interval between IDT24 for a drive in consideration of wavelength shortening in antenna reflector 27' and antenna reflector 26' may be satisfied.

[0056] The antenna reflector 27 and 27' reflect the 3rd surface acoustic wave in IDT22 side for detection and generate a standing wave of the 2nd surface acoustic wave between the antenna reflector 27 and 27'. The inter-electrode pitch  $P3$  is set as one half of wavelength  $\lambda_0$  of the 3rd surface acoustic wave and as for the antenna reflector 27 and 27' a number (this embodiment 100) of the line electrode D3 is set up so that bandwidth may become in less than  $2\Delta f$  so that center frequency may become frequency  $f_0$  of the 3rd surface acoustic wave.

[0057] Since the antenna reflector 27 and a reflexogenic-zone region of 27' are  $f_0 \times \Delta f$  ( $f_0 - \Delta f - f_0 + \Delta f$ ) The IDT23 for drive to 1st surface acoustic wave (frequency  $f_H = f_0 + \Delta f$ ) and the IDT24 for drive to 2nd surface acoustic wave (frequency  $f_H = f_0 - \Delta f$ ) are penetrated without being reflected by the antenna reflector 27 and 27' and are spread to antenna reflector 25 25' 26 and 26' side respectively.

[0058] The antenna reflector 27 so that a predetermined conditional expression of an interval between IDT22 for a drive in consideration of wavelength shortening in IDT23 for a drive and the antenna reflector 27 may be satisfied. It is formed in a prescribed position to IDT22 for a drive and antenna reflector 27' is formed in a prescribed position to IDT22 for a drive so that a predetermined conditional expression of an interval between IDT22 for a drive in consideration of wavelength shortening in IDT24 for a

drive and antenna reflector 27' may be satisfied.

[0059]In the above-mentioned composition if high frequency of frequency  $f_H$  and  $f_L$  is impressed to IDT23 for a drive and 24 respectively according to an inverse piezoelectric effect of the piezoelectric board 21 a substrate face will be displaced and the 1st surface acoustic wave and the 2nd surface acoustic wave will occur. For example in the case of a Rayleigh wave this wave has a displacement component in a direction and a direction of movement vertical to a substrate face and as shown in drawing 9 each particle in the surface of the piezoelectric board 21 draws an elliptical orbit rotated reversely to a direction of movement and is being displaced. Since a size of this elliptical orbit is small in a depth direction of the piezoelectric board 21 and the great portion of energy of a Rayleigh wave is concentrated on less than one wave of a depth direction a Rayleigh wave turns into a surface wave and advances.

[0060]The 1st elastic surfaces generated in IDT23 for a drive are spread from both sides of IDT23 for a drive to a longitudinal direction of the piezoelectric board 21.

[0061]In drawing 1 although the 1st surface acoustic wave spread rightward from IDT23 for a drive spreads a substrate face top in which IDT22 for detection IDT24 for a drive and antenna reflector 27' 26' and 25' were formed Since IDT22 for detection IDT24 for a drive and antenna reflector 27' and 26' have a reflexogenic-zone region in a frequency band of the 1st surface acoustic wave and a different frequency band and antenna reflector 25' has a reflexogenic-zone region in a frequency band of the 1st surface acoustic wave In these IDT22 23 and antenna reflector 27' and 26' it spreads to an antenna reflector 25' side without being reflected in IDT23 side for a drive and is reflected in IDT23 side for a drive by this antenna reflector 25'.

[0062]Although the 1st surface acoustic wave spread leftward from IDT23 for a drive spreads a substrate face top in which the antenna reflectors 27 and 25 were formed Since the antenna reflector 27 has a reflexogenic-zone region in a frequency band of the 1st surface acoustic wave and a different frequency band and the antenna reflector 25 has a reflexogenic-zone region in a frequency band of the 1st surface acoustic wave In the antenna reflector 27 it spreads to the antenna reflector 25 without being reflected in IDT23 side for a drive and is reflected in IDT23 side for a drive with this antenna reflector 25.

[0063]And since an interval between the antenna reflector 25 and 25' is set as a predetermined interval used as an integral multiple of wavelength  $\lambda_H$  of the 1st surface acoustic wave As shown in drawing 10 a standing wave of frequency  $f_H$  ( $=f_0 + \Delta f$ ) occurs between the antenna reflector 25 and 25' by interference with a progressive wave of the IDT23 for drive to 1st surface acoustic wave and a reflected wave of the 1st surface acoustic wave reflected by the antenna reflector 25 and 25'.

[0064]The 2nd elastic surfaces generated in IDT24 for a drive are also spread from both sides of IDT24 for a drive to a longitudinal direction of the piezoelectric board 21.

[0065]In drawing 1 although the 2nd surface acoustic wave spread rightward from IDT24 for a drive spreads a substrate face top in which antenna reflector 27' and 26' were formed Since antenna reflector 27' has a reflexogenic-zone region in a frequency band of the 2nd surface acoustic wave and a different frequency band and antenna reflector 26' has a reflexogenic-zone region in a frequency band of the 2nd surface acoustic wave In antenna reflector 27' it spreads to antenna reflector 26' without being reflected in IDT24 side for a drive and is reflected in IDT24 side for a drive by this antenna reflector 26'.

[0066]Although the 1st surface acoustic wave spread leftward from IDT24 for a drive

spreads a substrate face top in which IDT22 for detection IDT23 for a drive and the antenna reflectors 27 and 25 have a reflexogenic-zone region in a frequency band of the 2nd surface acoustic wave and a different frequency band and the antenna reflector 26 has a reflexogenic-zone region in a frequency band of the 2nd surface acoustic wave. In these IDT22, 23 and the antenna reflectors 27 and 25, it spreads to the antenna reflector 26 without being reflected in IDT24 side for a drive and is reflected in IDT24 side for a drive with the antenna reflector 26.

[0067] And since an interval between the antenna reflector 26 and 26' is set as a predetermined interval used as an integral multiple of wavelength  $\lambda_L$  of the 2nd surface acoustic wave. As shown in drawing 10a, a standing wave of frequency  $f_L (=f_0 - \Delta f)$  occurs between the antenna reflector 26 and 26' by interference with a progressive wave of the IDT24 for drive to 2nd surface acoustic wave and a reflected wave of the 2nd surface acoustic wave reflected by the antenna reflector 26 and 26'.

[0068] Between the antenna reflector 25 and antenna reflector 26', an interference wave of frequency  $f_0 (= (f_L + f_H)/2)$  occurs by interference with a standing wave of frequency  $f_H$  and a standing wave of frequency  $f_L$ .

[0069] Where a substrate face of the piezoelectric board 21 is vibrated by the above-mentioned interference wave, if this piezoelectric board 21 rotates, Coriolis force will act on this interference wave. This Coriolis force  $f_C$  is expressed with a vector type of the following \*\* with regards to the velocity of vibration  $V$  of particles which are carrying out the particle density  $\rho$  and an elliptic movement of the piezoelectric board 21 and angular-rate-of-rotation  $\omega$  of the piezoelectric board 21. It is shown in \*\* type that a sign of a block letter is a vector.

[0070]

[Equation 1]

[0071] Now a xy plane is shown in the surface of the piezoelectric board 21 and the z-axis. The normal line direction of the surface of the piezoelectric board 21. If the rectangular coordinate system of xyz which makes a x axis the direction of movement of the interference wave  $W$  is set up (refer to drawing 13), the velocity of vibration  $V$  of the particles which are carrying out the elliptic movement in xz side is separable into ingredient  $V_x$  of x shaft orientations and ingredient  $V_z$  of z shaft orientations.

[0072] Since a direction and the direction of the axis of rotation (z-axis) of velocity-of-vibration ingredient  $V_z$  are parallel when the piezoelectric board 21 rotates by angular-rate-of-rotation  $\omega_z$  around the z-axis as shown in drawing 11, only to velocity-of-vibration ingredient  $V_x$  of particles, Coriolis force  $f_{Cy} (= -2\rho \cdot V_x \text{ and } \omega_z)$  parallel to a xy plane which intersects perpendicularly with a x axis acts. About 90 degrees of phases shift to the interference wave  $W$  by an interaction of an elliptic movement of particles and rotational movement of the piezoelectric board 21 based on the interference wave  $W$  and it generates and this Coriolis force  $f_{Cy}$  becomes a surface acoustic wave spread with propagation of the interference wave  $W$  synchronizing with this as shown in drawing 12.

[0073] However, a surface acoustic wave (90 degrees of phases shifted in same frequency [ as the interference wave  $W$  ]  $f_0$  -- a surface acoustic wave.) based on the above-mentioned Coriolis force  $f_{Cy}$  in between the antenna reflector 27 and 27' (it is hereafter

called the 3rd surface acoustic wave.) -- since it is set as a predetermined interval used as an integral multiple of wavelength  $\lambda_0$  as shown in drawing 13a standing wave of the 3rd surface acoustic wave C based on Coriolis force  $f_{Cy}$  arises between the antenna reflector 27 and 27'.

[0074] Coriolis force  $f_C$  at the time of rotating by angular-rate-of-rotation  $\omega_x$  around a case where the piezoelectric board 21 rotates by angular-rate-of-rotation  $\omega_y$  around the y-axis and a x axis is as follows.

[0075] Namely when the piezoelectric board 21 rotates by angular-rate-of-rotation  $\omega_y$  around the y-axis Since the direction of the axis of rotation (y-axis) lies at right angles to both velocity-of-vibration ingredient  $V_x$  and  $V_z$  Coriolis force  $f_{Cz}$  ( $=2 \rho \cdot V_x$  and  $\omega_y$ ) and  $f_{Cx}$  ( $=-2 \rho \cdot V_z$  and  $\omega_y$ ) act to both velocity-of-vibration ingredient  $V_x$  and  $V_z$  respectively When the piezoelectric board 21 rotates by angular-rate-of-rotation  $\omega_x$  around a x axis since the direction of the axis of rotation (x axis) is parallel to the direction of velocity-of-vibration ingredient  $V_x$  Coriolis force  $f_{Cy}$  ( $=2 \rho \cdot V_x$  and  $\omega_x$ ) acts only to velocity-of-vibration ingredient  $V_z$  of particles.

[0076] Therefore if a vector type which writes a unit vector of each shaft orientations of a x axis the y-axis and the z-axis by  $i_x$ ,  $i_y$  and  $i_z$  and is shown by the above-mentioned \*\* formula is expressed with an all directions-oriented ingredient it will become like following \*\* type. It is shown in \*\* type that a sign of a block letter is a vector.

[0077]

[Equation 2]

[0078] From the above-mentioned \*\* type although Coriolis force  $f_C$  becomes a resultant force of the ingredient of each shaft orientations of a x axis the y-axis and the z-axis it can separate and detect each ingredient of Coriolis force  $f_C$  by setting the mutual relation between the polarization direction of the piezoelectric board 21 the electrode 23 for detection and the surface acoustic wave W as a predetermined relation.

[0079] Therefore in this embodiment the following explanation is carried out for the case of explanation where the piezoelectric board 21 rotates by angular-rate-of-rotation  $\omega_z$  around the z-axis for convenience to an example.

[0080] Drawing 13 is a figure showing the relation between the interference wave W and the 3rd surface acoustic wave C displaced to y shaft orientations produced by Coriolis force  $f_{Cy}$ .

[0081] 90 degrees of phases have shifted and the 3rd surface acoustic wave C displaced to y shaft orientations produced by Coriolis force  $f_{Cy}$  to the interference wave W displaced to z shaft orientations is a standing wave between the antenna reflector 27 and 27'. Since the Kushigata electrode D1 and D2 are formed in the position (namely position used as the belly of the 3rd surface acoustic wave C) used as the paragraph of the interference wave W IDT 22 for detection The Kushigata electrode D1 and the Kushigata electrode D2 are mutually displaced to an opposite direction by distortion of y shaft orientations resulting from the 3rd surface acoustic wave C (refer to the arrow direction of drawing 13) Voltage  $E_{DET}$  according to that amount of displacement occurs between the Kushigata electrode D1 and the Kushigata electrode D2 according to the piezo-electric effect of the piezoelectric board 21 and this voltage  $E_{DET}$  is detected as Coriolis force  $f_{Cy}$ .

[0082] As mentioned above the surface of the piezoelectric board 21 is made to generate a

standing wave of the 1st surface acoustic wave of frequency  $f_H (=f_0+\Delta f)$  higher than detection frequency  $f_0$  of Coriolis force  $f_{Cy}$  and the 2nd surface acoustic wave of frequency  $f_L (=f_0-\Delta f)$  lower than detection frequency  $f_0$ . While generating the interference wave  $W$  of detection frequency  $f_0$  by both elastic-surfaces wave interference. Since it was made to produce the antenna reflector 27 for exclusive use and a standing wave of the 3rd surface acoustic wave  $C$  that provides 27' and originates in Coriolis force  $f_{Cy}$  to Coriolis force  $f_{Cy}$  generated by an interaction of this interference wave  $W$  and rotational movement of the piezoelectric board 21A high level can detect Coriolis force  $f_{Cy}$  in which voltage conversion was carried out by the piezo-electric effect as much as possible without being influenced by the 1st and 2nd surface acoustic wave and an interference wave and thereby detection sensitivity can be raised.

[0083] By the above-mentioned embodiment as shown in drawing 1 on the right-hand side of IDT22 for detection have arranged antenna reflector 25' to the 1st surface acoustic wave in the outermost part and arranged the antenna reflector 26 to the 2nd surface acoustic wave in the outermost part on the left-hand side of IDT22 for detection but. If the 3rd surface acoustic wave that is an interference wave of the 1st surface acoustic wave and the 2nd surface acoustic wave may arise between IDT23 for a drive and IDT24 for a drive arrangement of the antenna reflector 25 25' the antenna reflector 26 26' and the antenna reflector 27 and 27' will not be limited to a relation position shown in drawing 1.

[0084] For example as shown in drawing 14 it may be made a relation position to which arrangement with antenna reflector 25' and antenna reflector 26' was changed in drawing 1 and as shown in drawing 15 in drawing 1 it may be made a relation position to which arrangement with \*\*\*\* 25 and the antenna reflector 26 was changed. As shown for example in drawing 16 may make it a relation position to which arrangement with antenna reflector 25' and antenna reflector 27' was changed in drawing 14 but. As for the antenna reflector 27 and 27' when the antenna reflector 25 of the 3rd surface acoustic wave resulting from Coriolis force  $f_{Cy}$  and transmission loss in 25' are taken into consideration arranging in the innermost part is preferred.

[0085] Drawing 17 is a lineblock diagram showing a 2nd embodiment of a surface acoustic wave gyroscope concerning this invention.

[0086] A 2nd embodiment is what reduced accuracy of a formation position of IDT22 for detection and connects the detector circuit 31 to the output terminal a of IDT22 for detection and a' in drawing 1.

[0087] Since frequency is the same as that of an interference wave of the 1st surface acoustic wave and the 2nd surface acoustic wave and the 3rd surface acoustic wave based on Coriolis force and 90 degrees of phases differ. If not correctly formed in a prescribed position to a standing wave of the 3rd surface acoustic wave that IDT22 for detection mentioned above an ingredient of a signal which carries out piezo-electric conversion of the interference wave will be contained in a detecting signal of IDT22 for detection. The detector circuit 31 removes a signal component based on an interference wave from a detecting signal from IDT22 for detection and extracts only a signal component based on Coriolis force.

[0088] The detector circuit 31 comprises the high-frequency oscillator 32 the phase shifter 33 and the differential amplifier 34 which generate high frequency of frequency  $f_0$ . The high-frequency oscillator 32 comprises an oscillator using the surface acoustic wave resonator theta of resonance frequency  $f_0$  as well as the high-frequency oscillators 3 and 4.

[0089]The phase shifter 33 amends a phase shift based on distance difference of IDT22 for detection of high frequency outputted from the high-frequency oscillator 32 and IDT23 for a drive and 24. The phase shifter 33 consists of an all path active filter of a phase leading form for example and can adjust a phase of high frequency from the high-frequency oscillator 31 to arbitrary phases by the variable resistor R1.

[0090]The differential amplifier 34 is what used the operation amplifier 34a the input resistance R1 and high frequency by which phase adjustment was carried out via R3 are inputted into - input terminal of this operation amplifier 34a and a detecting signal of IDT22 for detection is inputted into + input terminal via the resistance R4. The resistance R3 and R5 comprise a variable resistor in order to adjust an input level and a gain respectively.

[0091]The differential amplifier 34 Via the phase shifter 33 from level  $E_{DET}$  of Coriolis force (signal changed into high frequency of frequency  $f_0$  by the piezo-electric effect) detected by IDT22 for detection and the high-frequency oscillator 31. Level difference  $\Delta E (= E_{DET} - E_r)$  with level  $E_r$  of a standard height cycle of inputted frequency  $f_0$  is amplified and outputted.

[0092]As for the detector circuit 31 frequency of the high-frequency oscillator 31 and phase quantity of the phase shifter 33 are adjusted so that an output from the differential amplifier 34 may be set to "0" by a driving condition in the state where the piezoelectric board 21 has not rotated beforehand.

[0093]the above-mentioned composition \*\*\*\* -- high frequency of frequency  $f_0$  which carries out piezo-electric conversion being detected and Coriolis force from IDT22 for detection if the piezoelectric board 21 rotates Level difference  $\Delta E$  with level  $E_r$  of a standard height cycle of frequency  $f_0$  inputted from disregard level  $E_{DET}$  of this high frequency and the high-frequency oscillator 31 is amplified and outputted from the differential amplifier 34.

[0094]however a state where Coriolis force does not generate the detector circuit 31 -- that is an output from the differential amplifier 34 is set to "0" in the state where only a signal component based on an interference wave is detected from IDT22 for detection (a signal component based on an interference wave is canceled) since it is beforehand adjusted like Even if a signal component based on an interference wave is contained in a detecting signal of IDT22 for detection only a signal component corresponding to Coriolis force will be outputted and influence of an interference wave is not received from the detector circuit 31.

[0095]Therefore by adopting this detecting method also when accuracy of position of IDT22 for detection is not enough Coriolis force can be detected correctly.

[0096]Drawing 18 is a lineblock diagram of a 3rd embodiment of a surface acoustic wave gyroscope concerning this invention.

[0097]In drawing 1a 3rd embodiment IDT22 for detection of the surface of the piezoelectric board 21 IDT23 for a drive IDT24 for a drive the antenna reflector 25 25' In the antenna reflector 26 26' and the antenna reflector 27 and the direction (y direction) that intersects perpendicularly to an arrangement direction of 27'. IDT22 for detection IDT23 for a drive IDT24 for a drive the antenna reflector 25 25' While arranging IDT35 for detection which consists of the same structure as the antenna reflector 26 26' and the antenna reflector 27 and 27' IDT36 for a drive IDT37 for a drive the antenna reflector 38 38' the antenna reflector 39 39' and the antenna reflector 40 and 40' Each output terminal



b-b' of the high-frequency oscillator 3 and the high-frequency oscillator 4 and c-c' are connected to IDT36 for a drive and IDT37 for a drive respectively.

[0098] In a 1st embodiment since a surface acoustic wave spread to a x direction is used only a y direction ingredient of Coriolis force  $f_c$  is detectable but in a 2nd embodiment. Since a surface acoustic wave spread to a y direction is also used it can detect also about a x direction ingredient of output terminal d-d' to Coriolis force  $f_c$  of IDT35 for detection. Even if it uses the two gyroscopes 1 concerning a 1st embodiment that made intersect perpendicularly mutually and has been arranged same effect is acquired but. Since the gyroscope 1 for two pieces is constituted on the same piezoelectric board 21 according to a 3rd embodiment a miniaturization of a gyroscope and miniaturization are attained.

[0099] Although the above-mentioned embodiment explained a surface acoustic wave gyroscope of a type which detects Coriolis force by an interaction of the 1st and 2nd elastic-surfaces wave interference wave and rotational movement of the piezoelectric board 21 This invention is not limited to this can reflect a surface acoustic wave which the piezoelectric board 21 was made to generate with an antenna reflector can make it a standing wave and can be applied also to a surface acoustic wave gyroscope which detects Coriolis force by an interaction of this standing wave and rotational movement of the piezoelectric board 21.

[0100] For example as shown in drawing 19 it is applicable also to the conventional surface acoustic wave gyroscope which has a sensing element shown in drawing 21.

[0101] Drawing 19 constitutes the C-B Pierce type high-frequency oscillator 32 of oscillating frequency  $f_0$  which used the surface acoustic wave resonator theta (resonance frequency is  $f_0$ ) on the piezoelectric board 100 in drawing 21. A bias circuit of the high-frequency oscillator 32 is omitted. An outgoing end of the high-frequency oscillator 32 is connected to IDT102103 for a drive and high frequency of frequency  $f_0$  is impressed to IDT102103 for a drive.

[0102] Since the drift also of the resonance frequency  $f_0$  of the antenna reflector 104105 is carried out to  $(f_0 + \Delta f_t)$  when oscillating frequency  $f_0$  of the high-frequency oscillator 32 carries out a drift to  $(f_0 + \Delta f_t)$  by a temperature change The amplitude characteristic of a surface acoustic wave (standing wave) is stabilized and the temperature characteristics of detection sensitivity of Coriolis force improve.

[0103] If the detector circuit 31 is connected to a sensing element as shown in drawing 20 accuracy of position of IDT101 for detection to the antenna reflector 104105 can be reduced. Drawing 20 is connected to the phase shifter 33 of the detector circuit 31 while it connects to IDT102103 for a drive an output terminal of the high-frequency oscillator 32 formed in the piezoelectric board 21. Since a signal component on which a surface acoustic wave is based is canceled by the differential amplifier 34 this embodiment can also detect only a signal component corresponding to Coriolis force from a detecting signal of IDT101 for detection.

[0104]

[Effect of the Invention] As explained above the surface of this invention \*\*\*\*\* and a piezoelectric board is vibrated by the standing wave of a surface acoustic wave In the surface acoustic wave gyroscope which changes into an electrical signal the Coriolis force generated in the substrate face by the interaction of this vibration and rotational movement of a piezoelectric board according to the piezo-electric effect and detects it The

signal generating means which generates the signal equivalent to the vibration based on the above-mentioned surface acoustic wave in which voltage conversion was carried out by the piezo-electric effect. The signal output means which outputs the difference signal of the detecting signal from the electrode for detection and the output signal from a signal generating means which detect Coriolis force is established. Since reason \*\*\*\*\* was removed from the detecting signal from the electrode for detection to the surface acoustic wave which is a vibration source, also when the signal component resulting from a surface acoustic wave is contained in the detecting signal from the electrode for detection, Coriolis force can be detected correctly. This becomes possible to reduce the accuracy of the formation position of the electrode for detection.

[0105] The 1st electrode for a drive that generates the 1st surface acoustic wave on the surface of a piezoelectric board according to this invention. While arranging the electrode for detection which detects the 3rd surface acoustic wave resulting from the 2nd electrode for a drive and Coriolis force that generate the 2nd surface acoustic wave of different frequency from the 1st surface acoustic wave to a single tier on both sides of this electrode for detection, the [ the 1st of opposite structure which reflects the 1st - the 3rd surface acoustic wave respectively in order to make the both outsides of the 1st and 2nd electrode for a drive generate a standing wave - ] -- the electrode for antenna reflectors of three [ arrange and ] It makes the 1st and 2nd inter-electrode one for a drive generate the interference wave of the 1st and 2nd surface acoustic wave (standing wave). It is a surface acoustic wave gyroscope which detects the electrical signal which resonated the Coriolis force (standing wave of the 3rd surface acoustic wave) produced by the interaction of this interference wave and rotational movement of a piezoelectric board and was transformed into voltage by the electrode for detection. The signal generating means which generates the signal equivalent to the vibration based on the 3rd elastic surfaces in which voltage conversion was carried out by the piezo-electric effect. Since the signal output means which outputs the difference signal of the detecting signal from the electrode for detection and the output signal from the above-mentioned signal generating means is established and reason \*\*\*\*\* was removed from the detecting signal from the electrode for detection to the 3rd surface acoustic wave that is a vibration source. Also when the signal component resulting from the 3rd surface acoustic wave is contained in the detecting signal from the electrode for detection, Coriolis force can be detected correctly and this becomes possible to reduce the accuracy of the formation position of the electrode for detection.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is a lineblock diagram of the surface acoustic wave gyroscope concerning this invention.

[Drawing 2] It is a figure showing the electrode structure formed in the piezoelectric board.

[Drawing 3] It is a figure showing the basic circuit composition of the high-frequency oscillator using a surface acoustic wave resonator.

[Drawing 4] It is a figure showing other examples of the basic circuit composition of the

high-frequency oscillator using a surface acoustic wave resonator.

[Drawing 5] It is a top view showing the structure of a surface acoustic wave resonator.

[Drawing 6] It is a figure showing the mutual relation position of IDT for a drive of the couple to a surface acoustic wave.

[Drawing 7] It is a figure showing the definition of an interval with IDT for a drive and an antenna reflector.

[Drawing 8] It is a figure for explaining shortening of the wavelength of the surface acoustic wave in the metal tunic surface.

[Drawing 9] It is a figure showing displacement of the particles of the substrate face in a Rayleigh wave.

[Drawing 10] It is a figure showing the frequency of the standing wave generated between each antenna reflector.

[Drawing 11] It is a figure showing the generating direction of the Coriolis force to the elliptic movement of the particles by a surface acoustic wave.

[Drawing 12] It is a figure showing the elastic-surfaces wave propagation based on a surface acoustic wave and Coriolis force.

[Drawing 13] It is a figure showing the relation between an interference wave and the 3rd surface acoustic wave displaced to y shaft orientations produced by Coriolis force  $f_{Cy}$ .

[Drawing 14] It is a figure showing a 2nd embodiment of the locating position of the antenna reflector formed in the piezoelectric board.

[Drawing 15] It is a lineblock diagram of a 3rd embodiment of the locating position of the antenna reflector formed in the piezoelectric board.

[Drawing 16] It is a lineblock diagram of a 4th embodiment of the locating position of the antenna reflector formed in the piezoelectric board.

[Drawing 17] It is a lineblock diagram of a 2nd embodiment of the surface acoustic wave gyroscope concerning this invention.

[Drawing 18] It is a lineblock diagram of a 3rd embodiment of the surface acoustic wave gyroscope concerning this invention.

[Drawing 19] It is a lineblock diagram of a 4th embodiment of the surface acoustic wave gyroscope concerning this invention.

[Drawing 20] It is a lineblock diagram of a 5th embodiment of the surface acoustic wave gyroscope concerning this invention.

[Drawing 21] It is a figure showing IDT for detection IDT for a drive and the antenna reflector which were formed in the piezoelectric board of the conventional surface acoustic wave gyroscope.

[Description of Notations]

1 Gyroscope

2 Sensing element

3 high-frequency oscillator (1st high frequency creating means)

4 high-frequency oscillator (2nd high frequency creating means)

21100 Piezoelectric board

22 IDT for detection (electrode for detection)

23 IDT for a drive (1st electrode for a drive)

24 IDT for a drive (2nd electrode for a drive)

25 and 25' antenna reflector (1st electrode for antenna reflectors)

26 and 26' antenna reflector (2nd electrode for antenna reflectors)

27 and 27' antenna reflector (3rd electrode for antenna reflectors)  
28 IDT  
29 and 30 Antenna reflector  
31 Detector circuit  
32 High-frequency oscillator (high frequency creating means)  
33 Phase shifter (signal generating means)  
34 Differential amplifier (signal output means)  
34a Operation amplifier  
35 IDT for detection  
36 IDT for a drive  
37 IDT for a drive  
38 38' Antenna reflector  
39 39' Antenna reflector  
40 40' Antenna reflector  
101 Drive IDT (electrode for detection)  
IDT for 102103 drive (electrode for a drive)  
104105 Antenna reflector (electrode for antenna reflectors)  
theta Surface acoustic wave resonator

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